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ABSTRACT

This booklet cites evidence indicating that intelligence can be trained, given a physiologically normal student and an intensely persistant tutor. Methodologies for increasing mental efficiency have in common the principle of coordination of physical and mental processes, whether achieved by simple relaxation training, brain polarization, or biofeedback. Successful evidence and short descriptions of the processes are provided for transcendental meditation, yoga, hyponedia, Bulgarian suggestopedia, autogenic therapy, progressive relaxation, and biofeedback. Current applications of biofeedback, descriptions of biofeedback instruments, and suggestions for a hypothetical biofeedback learning center using relatively inexpensive biofeedback equipment are provided. Also included are a source and price list of biofeedback instruments and a list of recommended reading. (Author/DE)

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CAN INTELLIGENCE BE TAUGHT?

Thomas G. Sexton and
Donald R. Poling

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Phi Delta Kappa Educational Foundation

THOMAS G. SEXTON

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Thomas G. Sexton, a graduate of the University of Alaska, first became interested in the problem of fully utilizing and increasing human intelligence while shining brass doorknobs on a U.S. Navy cruiser in the South Pacific. Since that time, he has made the project central to his studies.

Among his accomplishments are the development of a teaching system for rapid arithmetic, an integrated system of mnemonics (memory keys) for retaining information in textbooks, and a program for teaching "solitaire brainstorming," for individual creative problem-solving. He is currently director of the Biofeedback Training Institute in Bloomington, Indiana.

Donald R. Poling, a graduate of Alaska Methodist University in Anchorage with a masters' degree in Instructional Systems Technology from Indiana University, is research assistant to Dr. Edmund Jacobson, M.D., in Chicago, who developed the system of *Progressive Relaxation* which is discussed at several points in this fastback.

He first became interested in the problem of enhancing human intelligence after being buttonholed by Tom Sexton in the A.M.U. cafeteria in Anchorage, Alaska, in 1966. Subsequently, he worked with Tom in the evenings after teaching fourth grade during the working day, developing curricula for teaching logic, spatial relations, and rapid reading. He has also written a program for teaching basic algebra to children.

CAN INTELLIGENCE BE TAUGHT?

by Thomas G. Sexton

and

Donald R. Poling

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THE PUZZLE

We are approaching a time in which intelligence can be taught. Recent discoveries are unlocking the cipher of ages. The puzzle:

A Zen master shows his disciples the way of nothingness.

In the Menninger Clinic at Topeka, Kansas, Swami Rama shows the assembled physicians his power to stop his heart for seventeen seconds.

A chimpanzee in California with half its brain removed solves problems twice as fast as its full-brained brothers.

Two German medical doctors discover the power of warm hands.

In Chicago, a physician discovers startling relationships between muscle and mind.

In Bulgaria, a "quack" who claims to teach a foreign language in thirty days is investigated by the politburo and subsequently funded to establish institutes in Moscow, Sofia, and Prague.

In Britain, a twenty-two volt battery is found to make dogs learn faster.

N.A.S.A. reports brain rhythm harmonies characteristic of genius.

A housewife in Dallas, a professor in Los Angeles, and a student in New York listen to the rhythms of their brains as they train for inner control of the mind.

In Wisconsin, I.Q. scores of ghetto infants jump fifty points.

A twelve-year-old girl who reads over 80,000 words per minute is discovered in Illinois.

All are pieces of a single puzzle, which begin to form a picture of how intelligence may be taught.

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INTELLIGENCE: BACKGROUND CONCEPTS

Let us take a look at this capacity called "intelligence" to see what is necessary to train it. Drive is an essential component of intelligence. The human being has been shown to possess a drive to seek novel forms of experience, and these novel and complex experiences are rewarding in their own right. This drive, variously termed curiosity, play, exploration, creation, or learning, is present at birth—not only in the human species but in lower animals as well. The basic motive to learn, therefore does not have to be acquired, but only directed; motivation itself is a given.

Intelligence, however, is much more than motivation. Intelligence can be related to (1) the amount of learning, (2) the integration of learning, and (3) the application of learning in a given amount of time. The slow learner sees most of the material presented to him as a series of random, unrelated pieces. The student of exceptional ability sees things as classes, systems, relationships, and analogies. His mental world is organized. Consequently, if we are to materially aid the functioning of intelligence, we must design curricula within a structure of related concepts.

And another variable affecting intelligence is time. The student must learn, integrate, and apply a fact before he has time to forget it.

During the learning process the progress of the student is aided by his attention to relevant cues. We could even say that control of mental states must be learned in order to focus sharply on relevant cues. Those cues which are not relevant to a learning task interfere with the learning of that task. Information that does not add detracts. Irrelevant cues are of three different kinds: emotional, physical, and mental.

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Irrelevant emotional cues will cause a distortion of emphasis, which will make relevant information harder to identify. For example, the student who has a negative emotional reaction to mathematics is handicapped because his attention is being distracted. Thus, in order to train intelligence we must teach control of emotional reactions.

Irrelevant cues also may be physical, such as fatigue, ill health, or hunger. Johnny cannot read if his stomach hurts. Before intelligence can be trained, physiological impediments must be eliminated.

Also in the class of irrelevant cues are false information and ideas, such as the idea that "pure aryan blood is superior." Since our knowledge may be faulty, we must teach our students to analyze data themselves, to continually question and test the validity of what they are taught. In order to evaluate what one has been taught, a certain integrity and independence of thought is essential. Therefore, to teach intelligence is to teach self-directed, self-disciplined, self-monitoring, and self-rewarding patterns of learning.

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EXPERIMENTAL TRAINING PROGRAMS

Intrigued with the problem of finding a method or system of training intelligence, the authors speculated that a curriculum could be devised to contain the elements essential to learning. The first model was Thurston's theory of intelligence, which included these seven factors:

1. Verbal comprehension
2. Word fluency
3. Number fluency
4. Memory
5. Visualization and spatial ability
6. Perceptual speed
7. Induction, or logic

To this list they added divergent thinking, or creativity. Subsequently, during the 1967-68 school year, the authors devised methods of teaching these factors and integrated them into a program for raising intelligence.

In the summer of 1968, the program was tested with thirteen students at the YMCA in Anchorage, Alaska. Unfamiliar at that time with the exact content of the I.Q. tests to be used, the researchers preserved their naivete until the tests were given, so as to avoid teaching test items.

The program concentrated primarily on vocabulary building (3,700 words), mathematical skills, and rapid reading (to reduce the speed factor on timed tests). After ten weeks of training, our students' mean I.Q. scores increased from an average of 116 to 141. Of these, five went off the top of the tests (the *Lorge-Thorndike* and *Primary Mental Abilities*). These five students were then given the *Concept Mastery Test*, which was designed

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by Lewis Terman to test the gifted. The five students emerged with scores ranging from 150 to 190+, and one student went off the top of the C.M.T.!

Other studies have shown that intelligence can be increased in children. For example, in 1968, at the University of Wisconsin, Rick Heber gave black ghetto infants of retarded mothers tutorial training involving intensive personal attention beginning shortly following birth. A control group of infants was given no such help. By the age of four, the experimental group had a mean I.Q. score of 128-130. The controls registered a mean of 80. These figures put the untrained children in the lower 10 percent of the general population, and the tutored children in the top 2 percent.

With this evidence, then, it seemed obvious that merely by providing instruction in content areas with personal attention, I.Q. scores could be increased, both in adults and children. Perhaps there were also physiological indicators of intelligence. and if so, the authors wondered whether these could be manipulated. A thorough search of the literature, including obscure journals on brain physiology, yielded a positive reply to both questions. There do exist physiological measures of intelligence, and these do involve variables, such as brain waves, which have proven to be trainable.

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INTELLIGENCE, EDUCATION, AND EASTERN MYSTICISM

Before discussing these trainable variables, however, we shall first turn to some disciplines from the Far East which gave the West its first glimpse of the human potential for learning to control the internal functions of one's own mind, body, and state of emotional balance. Disciplines which involve training of what is loosely called altered states of consciousness can be a powerful tool. Originating in the Far East, all of these disciplines have the following features in common:

1. An alpha brain wave pattern characteristic of a relaxed but alert state halfway between sleep and wakefulness
2. Rest, reduction of fatigue and energy loss
3. Diffuse awareness, without focus of concentration
4. Long-term effects from daily practice, which include:
    a. mental integration or clarity of thought
    b. emotional integration and balance
    c. more effective sleep
    d. increased resistance to stress, fatigue, and diseases
    e. better performance on tests of speed and accuracy.

Several of these mental disciplines will be discussed in the following sections of this booklet, along with the results of research studies on each system and educational applications which have been devised in the West.

Transcendental Meditation

Transcendental meditation is at present one of the most popular of the mental disciplines in the United States. Its educational

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benefits and implications have only recently been studied. Physiologist R. K. Wallace investigated experienced transcendental meditators and found a number of physiological changes which occurred as they meditated. Meditators' metabolic rates were reduced by an average of 20 percent, heart rate and respiratory rates decreased, and skin resistance (G.S.R.) increased, reflecting emotional calm. Alpha brain waves predominated; they were regular and higher in amplitude (strength) than those which usually occur in pre-sleep among nonmeditators. In addition, metabolic rates remained lower than those of nonmeditators during normal daily activities, indicating a lesser degree of nervousness and irritability, as well as a decreased tendency to experience fatigue. Apparently, the maintenance of an alert, resting alpha pattern—a state in which one does not worry—beyond the pattern experienced prior to sleep added a kind of rest which most individuals do not experience adequately during the day.

Testing transcendental meditators has produced findings pertinent to education. At the University of Texas, Shaw and Klob discovered that transcendental meditators have significantly faster reaction time than controls (.5 second for the group of meditators, .3 second for the meditators—a difference of 40 percent). The correlation between reaction time and intelligence gives small but positive results, usually hovering around +.40.

At the University of Sussex, Graham found that the ability to discriminate differences in the sounds of tones or musical notes was enhanced by 35 to 55 percent in meditators. And at UCLA, perceptual speed and accuracy were found by Blasdell to be vastly superior in meditators as opposed to nonmeditators. The meditators were able to solve almost three times as many problems as the controls in a given time.

At Berkeley, Abrams found that meditators who had trained two years or more outperformed nonmeditators on both long- and short-term memory tasks by 17 and 35 percent, respectively. Other research has shown meditation produces positive changes in personality and social adjustment.

In searching for the basic principles underlying such changes, we found some possible flaws in the research methods used in the studies. For example, Edmund Jacobson pointed out to the authors that (1) evidence is lacking that control groups were

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equivalent to the meditation groups prior to the meditation training, and (2) many of the results reported might be obtained simply by closing one's eyes and relaxing for twenty minutes twice a day, without a Maharishi or mantram chanting, particularly if this is done daily for an extended period of time.

At least, however, these studies reveal that even incomplete rest does rejuvenate, especially if it is taken in the middle of a working day. Beyond that, mental efficiency seems to have been increased by a regular, daily period of relaxation, during which mental repetition of a rhythmic mantra induces a state of mental neutrality free from other thought or worry. Western scientists have taken Eastern meditation techniques, removed all the religion and most of the philosophy, and yet have found that their experimentally modified meditation or relaxation programs still yield an increase in mental and physical efficiency, including measurable increases in I.Q. scores.

Yoga

The yoga masters perform unusual feats in the area of bodily control. Elmer and Alyce Green of the Menninger Foundation in Topeka, Kansas, have carried on research with Swami Rama, a yoga master. He volunteered to work with them in 1970, so that they could study physiological aspects of yoga practices. Swami Rama, now in his late forties, has trained in yoga since he was four years old, and not too long ago he has held the rank of an Associate Shankaracharaya (equivalent to a bishop) in India.

One of Swami Rama's most interesting demonstrations concerned hyponedia (sleep learning). The delta brain rhythm (one to three cycles per second) is associated with only the deepest state of sleep—one of unconsciousness or coma. Swami Rama, however, while in a delta state, was later able to recall correctly 85 percent of the material given to him by the Greens. This means he was able to learn material very well indeed in a mental state that to the average person is about as close to oblivion as possible.

The yogas have been developing these techniques longer than

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we have written records. One of these methods similar to the yogic sleep learning of Swami Rama has been well developed in eastern Europe with startling results.

Hyponedia

Over a decade ago there was a wave of popular interest in the educational merits of hyponedia. Many European and Soviet studies indicated that sleep learning was unexpectedly efficient in rapidly learning material involving memorization, such as foreign languages and history. However, American research has largely yielded equivocal or negative results. For this reason, hyponedia has fallen into the special limbo commonly reserved for ESP and hypnotic studies.

American research is curiously insular. For example, it was found that European studies left "sleep states" largely undefined in terms of a measurable behavior; the researchers in America, therefore, monitored their sleep learning subjects by an electroencephalogram (EEG). They then found that their subjects were not "learning" in the brain wave pattern they defined as "sleep" (delta: 0.5 to 3 cycles per second) but only in "presleep" (theta and alpha: 4-13 cycles per second) conditions. Many researchers then concluded that the vast stacks of research from Europe were largely invalid, and that sleep learning was chimerical.

The Russians subsequently pointed out (although no one was listening in America anymore) that most learning did occur in the alpha and theta states. These states were a *majority* of what is usually called sleep, and delta sleep was only a small portion (15 percent) of average adult sleeping time. They also demonstrated a well-known (to them and to European sources for thirty years, anyway) phenomenon: to wit, if one expects learning to occur, one should tell his prospective students that they are to be taught and tested. The American researchers did not do either. It is not overly surprising that the sleep learners who were unprepared for a learning situation or later tests failed to do as well as their European counterparts.

A third piece of information which the American researchers failed to take into their compilations, although it was known

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from published sources, was a curious "sleeper effect." It was discovered that students often did not do well on tests of sleep-learned material right after the material had been learned, but they usually showed best results twenty-four to forty-eight hours after this material had been acquired. The mechanisms for this sleeper effect are at present unknown, but that it is a common concomitant to hyponedia is unquestioned.

Since 1962 research on hyponedia in Europe and the Soviet Union has outstripped that done in the United States. Although there were and still are some dedicated and skilled American researchers in the field, hyponedia remains by and large an unexplored field.

Bulgarian Suggestopedia

Meanwhile, as the American behavioral scientists turned to what they considered more profitable lines of work, a Bulgarian at the University of Sofia, Georgi Lozanov, M.D., perfected his monumental contribution to accelerated learning which he termed "Suggestopedia."

Lozanov's technique is derived from his intensive study of a yogic technique of relaxation, Savasanna. Using special techniques of suggestion, the body and brain are taught to relax from all stress. For example, in learning a language, students are told to listen to a recording of soft music while ignoring a language tape which is read in a changing, but rhythmical pattern. Lozanov gives the rate of learning to be about sixty to seventy-five words or phrases per hour.

The mind, so unshackled, has been shown to be able to learn at a rate from five to fifty times faster and far more efficiently. Years of testing at the Medical Postgraduate Institute, The Science and Research Institute, and The Institute of Pedagogics in Sofia, Bulgaria, confirm that Lozanov's techniques work. As a result of the findings based on several thousand cases of subjects from all walks of life, the Bulgarian Ministry of Education established The Center for Suggestopedia.

What are the results of Suggestopedia? Records show hundreds of people had effortlessly learned a foreign language, the

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vocabulary and grammar of which were equivalent to a two to three year college course, in as little as sixty days! Furthermore, and for the educator even more impressive, followup studies revealed that as late as a year afterward virtually none of this material had been forgotten. Small experimental groups likewise were learning and retaining basic courses in mathematics, physics, and chemistry in a matter of a few weeks.

Educators from India, Germany, and Russia have visited Lozanov's institute and have established centers for Suggestopedia in their own countries. In the West, however, Lozanov's system has largely been ignored.

The full scope and limitations of this technique are at present unknown. Trying to establish limits in one series of experiments, Lozanov and his research associates in fifteen minutes taught volunteers fifteen lessons in French grammar, which included about 500 new words. Tests were given afterward and three days later. The results were rather encouraging. All the words had been retained.

Lozanov's success is based on the training of mental and physical focus. There are sound, common sense reasons why this method works. First, the student is in a receptive, nonemotional state of mind. Second, nothing except the subject at hand is mentally present; the music and changing rhythms merely act as an associative cue, just as the music in a song makes the words easier to recall. Finally, fatigue of a physiological nature has been minimized. As a result, the student actually feels refreshed at the end of two hours of instruction. The results obtained seem unbelievable only in reference to those we commonly see when fatigue, inattention, emotional blocking, and increasing boredom are the rule.

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THE SCIENCE OF WESTERN MEDITATION

Autogenic Therapy

In 1932, two German medical doctors, Wolfgang Luthe and Johannes Schultz developed a training method derived from early hypnotic therapies and techniques of Indian yoga meditation. This discipline, called Autogenic Therapy, basically consists of sitting in a chair or lying down for fifteen minutes a day while concentrating on feelings of warmth and heaviness in the extremities. These standard exercises are followed by meditation exercises, which involve various forms of visual and sensory imagery.

In over forty years of research, Luthe and Schultz have established that autogenic therapy has had long-term effects on the improvement of health, scholastic performance, emotional stability, athletic ability, and standardized test scores. In the area of emotional control, which is essential to the full development of human potentials (or in school, education of "the whole child"), autogenic training has been shown to simultaneously affect emotional balance, social competence, and athletic ability, as reflected in one study conducted in Japan. In 1959, G. Naruse, at the Kyushu Institute of Technology gave autogenic training to fifty-six Olympic and amateur athletes suffering from stage fright. These athletes were in the fields of free pistol, skiing, heavy gymnastics, judo, volleyball, diving, baseball, running, jumping, and weight lifting. As a result of the training, stage fright was eliminated in all but a few cases, and the athletes were able to perform much more consistently from one meet to the next.

In a continuation of this study, Z. Tomita randomly selected twelve swimmers out of a group of twenty-four for autogenic training. Tomita gave the Yatbe-Guilford personality inventory

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to all subjects both before and after the training program. There were no measurable changes in the control group. The trained group, however, showed statistically significant changes. Tendencies to depression, wide fluctuations in mood, inferiority, and social introversion were reduced to one chance in a hundred; nervousness and objectivity to one chance in twenty. All measures indicated an improvement in psychological and emotional balance.

In 1967, D. J. Sellars used autogenic training during summer sessions at Lewis and Clark College in Oregon, with 240 underachieving students, aged fourteen to twenty-five. Some of his findings, including a four-year followup, are as follows:

1) Of the 240 unsuccessful academic students, 92 percent were accepted into college and 85 percent received passing grades or better.
2) Following post-tests on the Minnesota Multiphase Personality Inventory, comparison of total means of all nine clinical scales showed a consistent decrease in the direction of more stable personality in all four years of the followup study.
3) Study habits (Wrenn Study Habits Inventory) improved by 86 percent.
4) Ability to concentrate improved 150 percent from a beginning mean of thirty-three minutes to a final mean of eighty-three minutes.
5) A 20 percent average increase of intelligence scores after a nine-week period of interpolated activities (not likely to be due to practice effect) was viewed as reflecting that the students were more relaxed and could make better use of their intelligence.

Wolfgang Luthe, currently at the University of Montreal medical school, has recently incorporated biofeedback training methods into his program. He used a tone from an EEG to signal trainees when they are maintaining the alpha rhythm characteristic of experienced meditators, and a thermometer feedback to signal the degree to which the skin temperature of the hands have increased. (One effect of "warm hands" is to relieve migraine headaches.) He has also used an electromyogram (EMG) to measure the degree of muscle relaxation. The overall result has been that training is both quicker and successful with a greater percentage of the population.

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Progressive Relaxation

Several years before Schultz published his first work on autogenic training, Edmund Jacobson, M.D., working in Chicago, developed a method he called "Progressive Relaxation." Unlike Schultz's passive process, this method consisted of an active psychomotor process of tensing and relaxing groups of muscles. Jacobson's method has an advantage over autogenic techniques in that it induces a more complete relaxation as measured on the EMG. (Originally invented by Jacobson in 1922, the EMG yields very precise measures of muscle tensions.) Progressive relaxation also bypasses some negative side effects which occasionally occur in autogenic training as a result of the intrusion of threatening dream material or hallucinations. Jacobson said in an interview that his method induces such a complete state of relaxation, that the "blank mind" sometimes spoken of in Eastern religious texts is well enough established that no intruding or disturbing thoughts can occur during training sessions.

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MEASURING AND TRAINING INTELLIGENCE BY EEG

The brain constantly emits waves at various frequencies, which may be detected by electrodes on the scalp and amplified to give either a pen recording or variable tone. These waves, discovered by Hans Berger in 1924, are of very low strength or amplitude, measuring in millionths of a volt. They are generally classified as follows:

Delta	½ to 3 cycles per second (cps)	Deep sleep
Theta	4 to 7 cps	Dream imagery Reverie Creative insight
Alpha	8 to 13 cps	Restful, diffuse attention
Beta	14 to 28 cps	Attention Concentration
Gamma	29 to 40 cps	Extreme agitation Exceptional focus

Intelligence has been found to be accompanied by characteristic brain rhythms and reaction patterns, many of which can be trained. For example, W. Grey Walter (*The Living Brain*, 1953) states that scientists and engineers tend to exhibit only the faster beta rhythms (above fourteen cps) and to lack alpha rhythms (eight to thirteen cps) which are more characteristic of artists and musicians. He noted that intelligence tests were skewed to report higher scores for beta individuals who had both good mental imagery and a preference for reading over listening.

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That these brain patterns can be changed by training was demonstrated by W. Sturm van Leeuwen in 1959 and later by Joseph Kamiya at the Langley Porter Neuropsychiatric Institute, who in 1966 began publishing papers on the teaching of predominantly beta-type individuals to produce and maintain an alpha rhythm. Later studies have conversely demonstrated that predominantly alpha-type individuals could be trained in beta.

Although it is not known exactly how the learning process occurs, these researchers established that if a light is made to go on or a soft tone is sounded when the desired brain wave occurs, most individuals can learn to keep the light or tone on. Subjectively, this is done by producing the inner "feelings" associated with the desired brain wave pattern.

With this trainability factor in mind, one might conclude that the most effective individuals would be those who could switch rhythms at will. This has been found to be so. While noting that scientists tend to be beta types, W. Grey Walter adds that his most brilliant colleagues, those "verging toward creative genius," tended to switch from alpha to beta and back constantly over ten-second time periods, as though they were switching gears to accomodate several concurrent lines of thought.

Another method of measuring intelligence has been developed by John Ertl in Toronto, Canada. His machine, based on neural reaction time, measures I.Q. directly from the amount of time it takes for the brain to react to a light flash (*Phi Delta Kappan*, October, 1972). Shorter reaction times indicate higher intelligence on this device, which he calls the "neural efficiency analyzer." Total time required to measure a person is about five minutes; I.Q. is read directly from a dial controlled by a computer hookup with an EEG device, which in turn records brain reactions from electrodes on the scalp.

Ertl's I.Q. index correlates from .67 to .90+ with current I.Q. tests. (Followers of the Arthur Jensen controversy on race and I.Q. will be interested to note that Ertl's device shows no racial difference in I.Q.) But the neural efficiency analyzer has one defect. It cannot measure about a third of the population, those people who exhibit alpha most of the time plus a number of

people whose reaction to the light flash is to go into an alpha rhythm. It seems that the light induces alpha in about 1/6 of the population while an additional 1/6 are alpha types.

Alpha types, not being visually oriented, tend to be nonreaders, and hence are artificially discriminated against on I.Q. tests. But racial distributions of alpha- and beta-type individuals in the general population have been found to be identical, even cross-culturally, to the extent that the proportions are the same in Africa, Europe, and the United States. (See Mundy Castle, "A Neuropsychological Study of Knysna Forest Workers," *Psychologica Africana*, 1962.) Thus, Jensen's conclusions are not supported by physiological measures of intelligence, which we believe are more accurate indexes of mental efficiency than paper and pencil tests.

Other correlates to intelligence are described in a N.A.S.A. paper, *Average Evoked Potentials* (Emanuel Donchin, ed., 1967). Specifically, the paper notes that "a harmony showing an exact multiple of simultaneous beta, alpha, and theta rhythms (for example; 20, 10, and 5 cycles per second, respectively) would predict a veritable genius" (p. 305).

Again, each rhythm has been shown to be trainable separately. Theta (four to seven cps), is a rhythm which is characteristic of reverie and creative insight, according to Alyce and Elmer Green, who have been doing research with theta training at the Menninger Foundation in Topeka, Kansas. However, training of all three rhythms in harmony has not yet been attempted, although this work is currently in the planning stages by the authors.

One additional physiological measure of intelligence has been identified using EEG. This is the difference in rhythm between the right and left hemispheres of the brain. In individuals of average intelligence, the left hemisphere does not appear to retain as much dominance over the right as it does with high I.Q. individuals. In 1969, at the Michael Reese Hospital in Chicago, Duilo Guiannitropani established that individuals with I.Q.'s of 119-143 showed a significantly faster rhythm in the dominant (left) over the subdominant (right) hemisphere of the brain, which did not occur in the lower (93-110) I.Q. group. Subjectively, the difference was explained in terms of coordination of function; during a thinking or problem-solving task, equal

use of both hemispheres requires communication between hemispheres, which slows down the thinking process. The development of dominance by the left hemisphere for abstract thinking functions thus reduces the time required for reaching solutions to problems. As a measure of intelligence this right-left hemisphere frequency difference yielded a +.72 correlation with the *Wechsler Adult* I.Q. scale.

The functioning of the brain hemispheres can also be trained. In 1971, Stuart Diamond and Graham Beaumont at University College in Cardiff, England, demonstrated that the two halves of the brain can be trained to process information separately and independently (*Nature*, July 23, 1971). In other words, when given two tasks to perform simultaneously, their subjects were able to perform each task (one visual, and one of a motor performance, sorting nuts and bolts) using the hemisphere which was naturally dominant for each task. Literally, they did two things at once. The method of training was simple: half of each eye was masked so that information relating to each of two tasks was available visually only to the hemisphere dominant for that task (left for visual, right for motor). Overall dominance of the left hemisphere was also noted. The left hemisphere proved to be better at assuming tasks usually performed by the right hemisphere than vice versa.

Knowing that each hemisphere can operate independently, it can be surmised that by connecting leads to both hemispheres, it should be possible by biofeedback from an EEG to "teach" one hemisphere to be dominant or subdominant in task performance. If this is done, then speed of thinking and reacting to stimuli may be enormously increased.

Polarizing the Brain

Another approach to the problem of mental deficiency is the induction into the scalp of very minute amounts of DC current from an ordinary twenty-two volt battery. After reduction of the current with a resistor, 100 to 650 millionths of an ampere of electricity are fed through electrodes, with the positive electrode above the eyebrow and the negative electrode on

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one leg. Discovered accidently by psychiatrists W. T. Redfearn and O. J. Lippold in Britain (*British Journal of Psychiatry*, 1964), this device was found to induce a mild euphoria. Even though the current is too slight to be felt, the investigators later found that it would relieve deep depression and increase rates of retention for memorized material. It is strong enough to restore memory in cases of amnesia, enable schizophrenics to communicate sufficiently to enter therapy, and alleviate depression in mental patients who had failed to respond to therapy, drugs, or electroshock treatments.

Other effects of polarizing the brain have included the acceleration of the healing process when the electricity is passed across surgical incisions and the acceleration of the learning process in dogs. The U.S. Air Force and Navy are currently carrying on experimental research with the device. No negative side effects have been reported to date, except in cases where the polarity is reversed (with the negative electrode on the scalp). Reversed polarity induces depression and reduces mental clarity. However, as a substitute for drugs which almost always have a negative side effect, the DC polarizer may have a very great potential for reducing the loss of human talent, particularly in cases of depression, mental fatigue, and perhaps it could even help reverse senility.

APPLICATIONS OF BIOFEEDBACK

Since the rate at which information can be gained is a crucial factor in the training of intelligence, the teaching of reading, still the primary means of acquiring information, is central to any educational program. The teaching of rapid reading, moreover, has successfully used biofeedback techniques.

The alpha rhythm has been associated with both rapid reading and eidetic (photographic) imagery in children, according to two studies emanating from the Langly-Porter Neuropsychiatric Institute in San Francisco (Kamiya and Salamy, unpublished papers, 1972). This data bolsters reports of incredibly high rates of reading demonstrated by several prodigies who have emerged from two training programs in rapid reading. The authors of these programs independently hit on the same idea; Florence Shale of Northwestern University and Vearl McBride at Culver-Stockton College in Canton, Missouri, both found that the principle of relaxation could be applied to rapid reading. Shale, who uses Edmund Jacobson's *Progressive Relaxation* as a prereading exercise, found that from 1 to 5 percent of her students developed the ability to read at rates over 20,000 words per minute. Her best student exhibited a straight alpha pattern while "reading" at an incredible speed. This girl, now age seventeen, also exhibited eidetic imagery while maintaining an alpha pattern when tested by Donald Poling in March, 1973.

Present indications are that most normal adults can be trained to read up to about 2,000 words per minute with present methods. At this level, a plateau exists, but may be surpassed by a combination of biofeedback training coupled with intensive practice,

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using very simple materials initially and escalating gradually into more technical reading.

In the present state of the art, much progress can be made by engaging in rigorous study of the prodigies, of the methods by which they are taught, and of the psychological and physiological conditions under which their performances occur. Educational researchers have at best been foolishly negligent in choosing to ridicule the pioneers in this area rather than seriously investigating the results of their work. A good chronicle of some of the problems encountered by the workers in this field may be found in Vearl McBride's current book, *Damn the System—Full Speed Ahead.*

But the teaching of reading is just one example of the many possible uses of biofeedback techniques. Some of the mental phenomena which have been found to relate to the learning process (i.e., intelligence), and which might be brought under greater control with biofeedback, are the following:

1. From studies on mixed rhythms
   a. Walter: training in increased mental flexibility, resulting in improved effective inteligence
   b. Walter: measurement of personality variables and thinking patterns which can be used in planning the most efficient mode (visual or auditory) of presentation of learning material to a given individual
   c. Walter: possibility of training a beta type in alpha waves and an alpha type in beta waves to increase an individual's overall mental capabilities
   d. N.A.S.A.: indications of increased mental power by harmonic training of alpha, beta, and theta frequencies.
2. Implications from Split Brain Research
   a. Diamond and Beaumont: increase in total brain capacity through training each hemisphere to perform a separate task simultaneously.
   b. Guiannitropani: possibility of increasing mental efficiency by training frequency differences in right and left hemispheres of the brain.
3. From studies in theta rhythms
   a. Green: improvement of long-term recall
   b. Green: control of physiological functions
   c. Green: facilitation of creative thinking

Other methods which might be accelerated by use of biofeedback include:

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1. Jacobson: *Progressive Relaxation*, and Luthe & Schultz: *Autogenic Therapy*
   a. Decrease in examination and study anxiety
   b. Emotional stabilization
   c. Increase in ability to concentrate
   d. Substantially improved performance on standardized written tests, including I.Q. tests
2. Lozanov: *Suggestopedia*—accelerated retention and acquisition
3. From studies on visual processes and perceptual speed:
   a. Schale, Salamy, & McBride: the ability to read or scan materials at extremely high rates
   b. Kamiya, et al: the possibility of training visual eidetic imagery, or preventing its loss in eidetic children
   c. Lippold & Redfearn: perceptual speed, recognition and integration, relief of depression.

It should be noted that the initial teaching with biofeedback has been tutorial. Group techniques will have to follow either programmed or language laboratory methods at present. Opportunities for the teacher as innovator have never been greater as biofeedback curriculum development covers both cognitive and affective domains. As the developers adapt better and more effective methods, confirmation of a student's results can be accurately and impersonally recorded—truly a breakthrough in education. We have only sketched a few suggestions for curriculum. The individual teacher however can do far, far more as he is an expert in his subject and only he knows what must be thoroughly mastered at each step.

Developments in biofeedback research suggest that a center for the learning of mental and physical control is presently a very real possibility. Even a school system on a relatively small budget can now obtain biofeedback instruments which are highly reliable, accurate enough for educational purposes, lightweight, and simple in operation. For example, an EEG student trainer model has been developed which trains for all major bandwidths and amplitudes with a choice of either light or audio feedback modes which weighs less than four pounds and sells for under $200.

The biofeedback control center may either complement the existing curriculum or be incorporated in it. Such a center could also be used by the community at large, faculty, and students alike.

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Whenever possible it pays in the long run to rent or buy equipment from a single reputable company. The practical reason for this is that biofeedback manufacturing technology is in its infancy. Almost every company makes its equipment modular and interchangeable. The electrodes for the EMG of a given company may be transferred without fuss into the EEG in order to monitor brainwaves instead of muscle potential. Unfortunately, much of this modular equipment will only work together if it is manufactured by the same company.

A general outline for the curriculum possibilities involving biofeedback might include the items listed in the following table:

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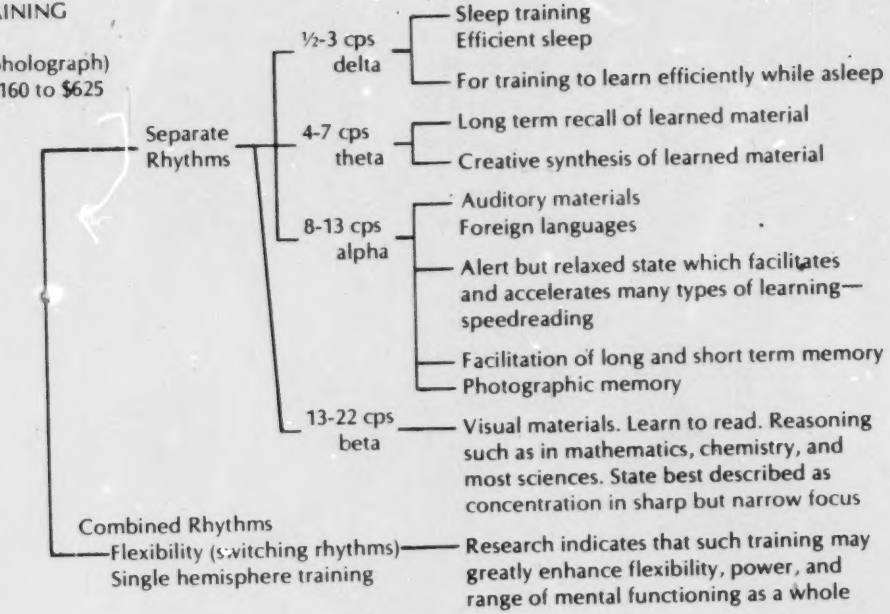
Biofeedback Devices

MENTAL TRAINING
—EEG—
(Electroencephalograph)
Priced from $160 to $625


Separate Rhythms
½-3 cps delta
Sleep training
Efficient sleep
For training to learn efficiently while asleep
4-7 cps theta
Long term recall of learned material
Creative synthesis of learned material
8-13 cps alpha
Auditory materials
Foreign languages
Alert but relaxed state which facilitates and accelerates many types of learning—speedreading
Facilitation of long and short term memory
Photographic memory
13-22 cps beta
Visual materials. Learn to read. Reasoning such as in mathematics, chemistry, and most sciences. State best described as concentration in sharp but narrow focus
Combined Rhythms
Flexibility (switching rhythms)
Single hemisphere training
Research indicates that such training may greatly enhance flexibility, power, and range of mental functioning as a whole

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Physiological—Emotional Training

Instrumentation	*Function*	*Description*
EMG (Electromyogram) Priced from $400 to over $800	Muscle Control Emotional Control	Most versatile instrument available for physiological and emotional training. Prior research on relaxation training indicates positive results (over 3,000 cases) in treatment of fatigue, worry, test anxiety, and so on. Experimental group had 38 percent less absenteeism from class as opposed to controls. Improved stamina on athletic performances is noted. Better sleep (on several measures) was reported in 83 percent of experimental group (Source: U.S. Navy Air Force)
Thermister Priced from $150 to $250	Temperature Control Physiologic	One of the newest and most promising instruments. Preliminary results indicate some value in autoregeneration of metabolism, male fertility, and migraine headaches
EKG (Electrocardiogram) Can be built for under $70	Heart Rate Control	Limited use in education at present. Clinical application to some forms of heart disease
GSR Priced at about $20	Arousal Level Control	Anxiety control. Some use in treatment of stage fright. Arousal, alertness.

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SUMMARY AND CONCLUSIONS

The first sections of this booklet cite evidence indicating that intelligence can be trained, given a physiologically normal student and an intensely persistent tutor. A number of methodologies for increasing mental efficiency have in common the one principle of coordination of physical and mental processes, whether achieved by simple relaxation training, brain polarization, or biofeedback. Finally, a hypothetical learning center could be started by using relatively inexpensive equipment which is currently available.

The purpose of increasing human intelligence, competence, or potential is to insure that the human race will continue to evolve in a positive direction, solving any problems which may present themselves as a threat to comfort or survival. The affective or emotional aspect is central, as is demonstrated by the enhancement of mental efficiency, which has stemmed from the psychologically levelling meditation techniques cited. We believe that to be happy, a human being must not only be physically comfortable, but must have the satisfaction of being able to accept the challenge of assuming responsibility for solving problems, great or small.

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Appendix A

Apparatus Source List

EEG: Plans for a feedback EEG appear in *Popular Electronics* (Jan., 1973), which may be built in kit form for $60. This device is inadequate for fine measurements, but may be used as an electrocardiograph (heart rate) or GSR feedback unit as well.

EMG: One may build a simplified but generally adequate feedback EMG for about $100 or less from a schematic printed in the *Journal of Behavior Therapy and Experimental Psychiatry,* Vol. 2 (1971).

GSR: Simple GSR units may be bought in toy stores as "lie detectors" (they do work!) for $10-20, or a very professional instrument can be built from schematics in the *Psychophsiology* (Nov., 1969). A very basic unit can be built for $3.00 from a schematic in the *Popular Electronics* (March, 1973).

Temperature: One may build a thermometer feedback unit from plans for about $5-30. Or if in a college, such an instrument can usually be borrowed from the physics or engineering department. Plans for a low-cost device (an electronic thermometer which is very sensitive to small temperature changes) appear in *Popular Electronics* (June, 1973).

To lease or buy biofeedback instruments of professional quality, we would recommend the following sources among others:

Autogenic Systems, Inc.
374 Colusa Avenue
Berkeley, California
94707

Biofeedback Technology, Inc.
10402 Trask Avenue
Garden Grove, California
92643

Inexpensive wireless systems for large groups of thirty or more:

Beckman Instruments, Inc.
Spinco Division
1117 Calif. Avenue
Palo Alto, California
94304

E3M Instrument Co.
P.O. Box 12511
7651 Airport Boulevard
Houston, Texas
77017

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RECOMMENDED READING

Barber, T. (Ed.), *Biofeedback and Self-Control.* Aldine Annual, Vol. 1, 1971, and Vol. 2, 1972. Chicago: Aldine-Atherton Publishing Company.

These volumes represent the most comprehensive collections of recent research papers available on biofeedback. Some papers are rough sledding for the non-specialist, but all are rewarding. Highly recommended.

Jacobson, Edmund (M.D.), *Progressive Relaxation.* Chicago: University of Chicago Press, 1938. *Anxiety and Tension Control.* Philadelphia: Lippincott Publishers, 1964. *The Biology of Emotions.* Springfield, Ill.: Charles C. Thomas, 1967.

This trio of books covers nearly half a century of research on the applications of relaxation training in medicine, psychology, and education. Techniques for training are carefully itemized. The implications of Jacobson's work for the field of education were revolutionary in 1938. They still are. Soon to be published is an additional volume devoted entirely to education and learning.

Lawrence, Jodi, *Alpha Brain Waves.* New York: Avon Books (paperback), Nash Publishing Company, 1972.

A good introductory book for the layman, this paperback gives a very readable summary of current applications and implications of biofeedback. Included is a chapter on applications to education, plus a fascinating bibliography of current research.

Lozanov, Georgi, *Suggestology and Suggestopedia.* Sofia, Bulgaria: University of Sofia Institute of Suggestology, 1969.

This book may be ordered through bookstores, or directly from Bulgaria. Chapter summaries are in English, and a complete English translation is to be available soon. Outlines the methods and results of suggestopedia; some of the methods used (including hypnosis) would require the services of a psychologist for screening and counseling of students.

Luthé, W., and Schultz, J., *Autogenic Therapy,* Vols. I-VI. New York: Grune & Stratton, 1969-1971.

These volumes contain the most exhaustive study (2,450 references) ever made on the medical, psychological, and emotional effects of meditation training. Includes applications to educa-

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tion, particularly in Volume III. Much of the material is highly technical and theoretical, and the translations from German often make for laborious reading. However, these volumes are a a goldmine of information, which is best prospected by judicious use of the index and chapter outlines. Luthe is currently using biofeedback to shorten the autogenic training method from approximately a year to a matter of weeks, and may be expected to publish again soon.

McBride, Vearl G., *Damn the System—Full Speed Ahead.* Jericho, N.Y.: Exposition Press, 1973.

Here in the full light of day is an angry, honest man. Methods for training rapid reading (in print and for braille), spelling mastery, and rapid arithmetic are given, with specific instructions for classroom teaching. Included with these are scathing denunciations of present practices on the elementary school level, particularly with regard to the quashing of unusual talent and ability.

Ostrander, Shelia, and Schroeder, Lynn, *Psychic Discoveries Behind the Iron Curtain.* Englewood Cliffs, N.J.: Bantam Books (paperback), Prentice-Hall, Inc., 1971.

Chapter 2, on Bulgaria, contains the most easily available description in English, of Georgi Lozanov's methods of Suggestopedia and Suggestology. Includes brief explanations of approaches taken by Lozanov in the training of artistic and musical abilities.

Schale, Florence, *Rapid Reinforced Reading Manual.* Chicago: Northwestern University Evening Division, 1970.

This manual is available from Northwestern University Evening Division accompanied by a text with multiple-choice comprehension questions, for $3.00. The kit includes materials for a six-weeks program for high school and adult instruction. The program includes use of a brief form of Jacobson's Progressive Relaxation. We have used these materials successfully with bright sixth grade students as well as adults.

Walter, W. Grey, *The Living Brain.* New York: W. W. Norton & Company, 1953.

A very interesting and lucid account of the history and nature of brain wave and encephalographic research. Explains very simply the meaning of various mental states as measured by EEG equipment. Recommended as good source for gaining a basic understanding of this complex field.

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